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AN ANALYSIS OF INTERNATIONAL CONSUMPTION FUNCTIONS

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I. INTRODUCTION

Since the 1930's a considerable amount of econometric analysis has been devoted to the estimation of consumption functions using macroeconomic time series variables. The results of the studies in this area have generally been interpreted as showing a significant relationship between national income and aggregate consumption. It is frequently claimed (see FRIEDMAN [1957]) that the estimated relationship takes a 'behavioral' form which derives in some way from the consumption behavior of individuals. However, the empirical studies of which we are aware use seemingly inappropriate statistical methodology, and have been lacking in justification of the aggregation from individual behavior to national accounts which is necessary to give the results their 'behavioral' content.

The purpose of this article is to show that there is very little real evidence in the data to support the view that variation in aggregate consumption can be satisfactorily described by variation in national income. This result does not imply anything about the determinants of individual consumption since the data do not on theoretical grounds seem to represent a valid aggregation of data for individuals. The theoretical problems of aggregation which are relevant to this point have been studied principally by NYBLÉN [1951] and THEIL [1954], to whom the reader is referred for detailed analysis. On the basis of the empirical results presented here and the theoretical work by NYBLÉN it seems to us difficult to support the view that a meaningful dependence between national income and consumption is at present justifiable on either theoretical or empirical grounds.

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II. ANALYSIS OF THE SIGNIFICANCE OF REGRESSION RELATIONSHIPS

Frequently, classical tests of significance have been applied to the results obtained from the estimation of macro-economic consumption functions[1]. These tests assume that the independent variables are observed without error, the error terms for each observation on the dependent variable are uncorrelated, and that the error terms are normally distributed with constant variance. It seems to us somewhat unlikely that these assumptions would normally be met for many of the economic time series which have been used in studies of the consumption function. For this reason we have considered more robust ways of examining the significance of the results of such correlation and regression studies[2].

In order to construct tests that do not depend on the classical assumptions of significance testing, we must attempt to assess the variability of the estimates from the information in the sample. Particularly simple tests which do not depend on the distribution of the residuals can be conducted with international macroeconomic data on income and consumption. Procedures with similar objectives were employed by PFANZAGL [1963] in his study of the relationship between aggregate income and price inflation.

To investigate the significance of a regression between two variables it is natural to ask if the observed result is different from the result that would be observed if there were no linear relationship between the variables. Suppose that we consider consumption functions of the form

$$C_{it} = \alpha_{ij} + \beta_{ij} Y_{jt} \tag{2.1}$$

where C_{it} is consumption in country i at time t and Y_{jt} is income in country j at time t. It seems reasonable to suppose that no relationship exists when $i \neq j$ or at the very least that C_i and Y_j are less highly correlated when $i \neq j$ than when $i = j$. From a number of such 'null-hypothesis' regressions, we can infer the average values and the

1. For a survey of macroeconomic consumption functions, the reader is referred to SUITS (1963).

2. Estimates of the significance of results are termed robust if they are insensitive to the distribution of the errors in the variables.

variability which we would expect if there were no relationship between the variables. It may be that international trade effects introduce some inter-correlation among the variables. However, it seems unlikely these correlations would be large enough to seriously affect our results. In particular the work of MORGENSTERN [1963] indicates that it is unlikely that the behavior of national accounts data can be greatly affected by reported variation in international trade statistics since these data contain very large errors.

The results of computing international consumption functions are given in *Table 2.1* for the original data and in *Table 2.2* for first differences of the data[3]. The entries in these tables are squared correlation coefficients with the element in the (i, j) position corresponding to the regression of the consumption of country i on the income of country j. The additional column on the right shows the regression coefficient obtained by regressing the consumption of country i on its own income.

The national consumption functions (entries in the last column and along the main diagonal of *Table 2.1*) are consistent with the results of YANG [1964]. However, it is clear from *Table 2.1* that, with the exception of Australia[4], the income of any country is about as good as the income of any other in describing consumption of a given country. In fact, in only four of the twelve countries is the coefficient of determination obtained from the regression of the country's consumption on its own income higher than all of the other off-diagonal coefficients of determination. This provides rather strong evidence to support the hypothesis that the regressions giving rise to the diagonal elements do not indicate a significant dependence between the two series. In contrast to this conclusion, it might be noted that using classical significance tests the null-hypothesis that $\alpha_{ii} = \beta_{ii} = 0$ would

3. The data on which the regression results are based are private consumption expenditures and disposable income, both in current dollars, for the period 1950–1963. The 1950–54 data were obtained from the *1957 Yearbook of National Account Statistics of the United Nations*. The data for 1955–63 were obtained from the 1964 Yearbook. No adjustments were made for price-level or exchange-rate changes.

4. The relatively low correlation between income and consumption in Australia may be explained in part by institutional factors determining farm income which is approximately 20 per cent of disposable income. When non-farm disposable income is used, the R^2 is increased substantially. For a discussion of this point see KMENTA (1966).

Table 2.1

International Consumption Functions

Values of R^2 and regression coefficients

Consumption		Income 1	2	3	4	5	6	7	8	9	10	11	12	$\hat{\beta}$
Australia	1	0.49	0.99	0.99	0.92	0.96	0.93	0.98	0.98	0.92	0.98	0.99	0.99	0.85
Austria	2	0.52	1.00	0.99	0.96	0.99	0.97	0.99	0.98	0.96	1.00	0.99	0.99	0.90
Canada	3	0.48	0.99	1.00	0.93	0.98	0.94	0.99	0.98	0.93	0.98	1.00	0.99	0.94
Denmark	4	0.53	0.94	0.94	1.00	0.98	0.99	0.97	0.96	0.99	0.97	0.95	0.96	0.88
France	5	0.54	0.98	0.98	0.98	1.00	0.98	0.98	0.97	0.98	0.99	0.98	0.99	0.90
Japan	6	0.57	0.96	0.95	0.98	0.98	1.00	0.97	0.97	0.98	0.99	0.96	0.97	0.75
Netherlands	7	0.45	0.98	0.97	0.97	0.98	0.97	0.99	0.99	0.97	0.99	0.98	0.98	0.85
New Zealand	8	0.50	0.98	0.97	0.93	0.96	0.95	0.99	0.97	0.93	0.98	0.98	0.99	0.87
Philipines	9	0.54	0.97	0.97	0.98	1.00	0.99	0.98	0.97	0.99	0.99	0.98	0.98	0.89
Sweden	10	0.55	0.99	0.99	0.97	0.99	0.98	0.99	0.98	0.97	1.00	0.99	0.99	0.81
U.S.	11	0.49	0.99	0.99	0.95	0.98	0.96	0.99	0.99	0.95	0.99	1.00	1.00	0.93
U.K.	12	0.48	0.99	0.99	0.95	0.98	0.95	0.99	0.99	0.95	0.99	1.00	1.00	0.89

be rejected in all cases, even for Australia, at the 1 per cent level. It is important to note the fact that we find evidence to support the hypothesis that *these regressions* are not significant does not imply that consumption does not depend on income, or even that other data could not show this dependence.

The table of coefficients of determination from first differences *(Table 2.2)* shows results that are more variable, and therefore deserve more study. For the first-differenced form of the consumption function, seven of the twelve countries have 'own' coefficients of determination which exceed the largest coefficients obtained by regressing consumption on the income of each of the other countries. We can estimate the behavior of the diagonal elements by computing their mean and standard deviation. The same statistics can be computed for disjoint combinations of twelve off-diagonal elements. The off-diagonal elements which were chosen are the elements in the diagonals which result from repeating the matrix to the right. This procedure yields eleven disjoint combinations with twelve off-diagonal terms each. The results of these combinations are as follows:

diagonal mean	0.52
diagonal s.d.	0.33
off-diagonal mean	0.19
off-diagonal s.d.	0.12

Since the observations on the diagonal have both a higher mean *and* a higher standard deviation, we are led to infer that *some* countries appear to exhibit a significant dependence between their income and consumption series. However, the high variability of these numbers indicates that the strength of the dependence is variable over countries. Inspection of the original table also supports this view.

Table 2.3 summarizes the information in *Table 2.2* by giving the rankings of the correlation coefficients which appear on the diagonal in *Table 2.2*. These coefficients were ranked both by rows and by columns. The row ranking indicates how many other income series (Y_j) were more highly correlated with a country's consumption (C_i) than was its own income (Y_i). The column rankings indicate the number of other country's consumption series that are more highly correlated with a country's income than is its own consumption. On both rankings over half of the countries have higher correlation

Table 2.2
International Consumption Functions
Values of R^2 and regression coefficients for first differences
(* indicates a value less than .01)

Consumption		Income 1	2	3	4	5	6	7	8	9	10	11	12	$\hat{\beta}$
Australia	1	0.03	*	*	*	*	*	0.04	0.12	*	0.01	0.16	0.04	0.02
Austria	2	*	0.65	0.09	0.16	0.49	0.39	0.10	0.03	0.15	0.79	0.18	0.14	0.59
Canada	3	0.05	0.17	0.39	*	0.40	0.05	0.05	0.02	0.11	0.35	0.39	0.04	0.27
Denmark	4	*	0.02	0.02	0.76	0.34	0.65	0.24	0.14	0.58	0.30	0.11	0.13	0.81
France	5	0.06	0.14	0.20	0.26	0.89	0.48	0.07	*	0.52	0.58	0.18	0.14	0.82
Japan	6	0.03	*	*	0.45	0.37	0.86	0.28	0.26	0.66	0.42	0.06	0.30	0.73
Netherlands	7	0.10	0.18	*	0.20	0.21	0.42	0.57	0.28	0.39	0.35	0.19	0.23	0.74
New Zealand	8	0.01	0.04	0.02	*	*	0.03	0.50	0.01	0.01	0.01	0.03	0.01	0.10
Philipines	9	0.02	0.14	0.05	0.20	0.44	0.52	0.31	0.07	0.70	0.38	0.29	0.14	0.66
Sweden	10	0.12	0.21	0.17	0.29	0.65	0.54	0.03	*	0.49	0.69	0.17	0.18	0.61
U.S.	11	0.07	*	0.11	0.13	0.13	0.13	0.03	0.41	0.13	0.10	0.69	0.01	0.82
U.K.	12	0.19	0.04	0.03	0.23	0.24	0.29	0.39	0.19	0.43	0.24	0.21	0.03	0.13

coefficients when both series are from the same country. However, in five cases on the row ranking and four on the column ranking this is not the case. This table helps to indicate the variability of correlations between the two series within one country.

Table 2.3

Ranking of own country's correlation coefficients
(from Table 2.2)

Rank of own R^2	*Number of countries*	
	by rows	by columns
first	7	8
second	3	1
third	1	0
fourth	0	1
fifth	0	0
sixth	0	0
seventh	0	1
eighth	0	1
ninth	0	0
tenth	1	0
	12	12

Since the simple regressions which we have just discussed indicate substantial variability in the correlation of each country's income with its own consumption, we investigated this evidence somewhat further. We performed stepwise regressions for each consumption series using the twelve income series as independent variables. The results of these regressions are shown in *Table 2.4*. The results shown are for the regression using first differences at the stage where the own country's income series entered the regression except for Canada and New Zealand which—due to multicollinearity and few degrees of freedom—did not have their own income series enter the regression until so many variables had been entered that the results were no longer meaningful. In the case of Austria (country 2), for example, the income of Sweden (country 10) was the first variable to enter the regression and Austria's income was the second variable to enter. At this point the partial r^2 is 0.64 for Swedish income and 0.40 for

Table 2.4

Multiple Regressions on First Differences at Point Where Own Income Entered the Regression

Consumption	Income 1	2	3	4	5	6	7	8	9	10	11	12	Multiple R^2
Australia 1 partial r^2 order of entrance of variables regression coefficient	.24 5 .05		.31 2				.28 4				.52 1	.37 3	.62
Austria 2		.40 2 .28								.64 1			.87
Canada 3	4	9		3	1	6	7	10	8	11	2	5	1.00
Denmark 4				.76 1 .81									.76
France 5					.89 1 .82								.89
Japan 6						.86 1 .73							.86
Netherlands 7							.57 1 .74						.57
New Zealand 8	3	8	6	7	5	10	1		2	11	4	9	.83
Philipines 9									.70 1 .66				.70
Sweden 10										.69 1 .61			.69
U.S. 11											.69 1 .82		.69
U.K. 12	.52 2	.24 3							.68 1			.16 4 −.18	.76

Austrian income. The regression coefficient of Austrian income is 0.28 as opposed to a coefficient of 0.56 obtained from regressing Austria's consumption on its own income.

Of the twelve series, seven had their own income series enter the regression first. One such country is Denmark in which case the r^2 is 0.76 and the regression coefficient is 0.82. In none of the cases where the own income series did not enter first was the final partial r^2 of own income higher than any other partial r^2 in the regression.

III. CONCLUSION

This paper has been concerned with the problem of significance tests of the Keynesian consumption function. Since the error terms are not likely to satisfy the conditions on which classical significance tests depend, a more robust way of examining the significance of regression results was proposed. For the consumption function, the test involves a comparison of the squared correlation coefficients obtained from regressing the consumption of country i on the income of country i with those obtained by regressing the consumption of country i on the income of country j for $j \neq i$. For a statistically significant result, we require that own country income be more highly correlated with consumption than other-country income.

Using time series observations on consumption and income, we cannot infer from our results that regressions involving the same country's consumption and income indicate a significant dependence between the two series. The results obtained from an analysis of first differences of the series suggest that there is some relationship between the own country variables but that the strength of the association is highly variable from one country to another. Since similar national accounting practices were used in all countries, differences in these practices are probably not responsible for the observed variation in correlations. These differences may be associated with a loss of information due to aggregation or errors in the accounting or statistical procedures.

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SUMMARY

Consumption functions form a major component of modern macroeconomic theory. The considerable amount of econometric evidence that has been accumulated since the 1930's has generally been interpreted as showing a significant relationship between national income and aggregate consumption. Frequently, classical tests of significance have been applied to the results obtained from the estimation of aggregate consumption functions. However, it seems unlikely that the assumptions underlying these classical tests are satisfied by the economic time series which have been used in these studies. This paper is concerned with more robust ways of examining the significance of such correlation and regression studies.

The test that is used in this paper involves the estimation of 'international' consumption functions; that is, the consumption of country i is regressed on the income of country j. In order for the data to indicate a significant consumption function, we require that own-country income ($j=i$) be more highly correlated with consumption than other-country ($j \neq i$) income. Using time series on aggregate consumption and income, it is not possible to infer from our results that the regressions which involve the same country's consumption and income indicate a significant dependence between the two series. The result obtained from analysis

of first differences of the series indicates that there is some relationship between the own-country variables, but that the strength of the association is highly variable from one country to another.

ZUSAMMENFASSUNG

Konsumfunktionen sind eine der Hauptkomponenten der modernen makroökonomischen Theorie. Seit den dreissiger Jahren sind zahlreiche Versuche gemacht worden, Konsumfunktionen empirisch zu verifizieren. Bei der Interpretation der Ergebnisse glaubte man meist, einen signifikanten Zusammenhang zwischen dem Volkseinkommen und dem aggregierten Konsum feststellen zu können. Resultate aus Schätzungen mit aggregierten Konsumfunktionen wurden häufig mit klassischen Signifikanztests geprüft. Den Annahmen dieser Tests werden die dieser Studie zugrunde liegenden ökonomischen Zeitreihen wahrscheinlich nicht genügen. Der Artikel entwickelt daher eine gröbere Methode, um die Signifikanz von Korrelations- und Regressionsstudien zu testen.

Der Test, der im vorliegenden Artikel gebraucht wird, baut auf der Schätzung einer 'internationalen' Konsumfunktion auf. Es wird eine Regression zwischen dem Konsum des Landes i und dem Einkommen des Landes j berechnet. Eine Konsumfunktion gilt dann als signifikant, wenn der Konsum eines Landes mit seinem eigenen Einkommen ($j = i$) jeweils stärker korreliert ist als mit demjenigen eines andern Landes ($j \neq i$). Aus den Ergebnissen der vorliegenden Untersuchung lässt sich nicht schliessen, dass die Regression, die jeweils Konsum und Einkommen des gleichen Landes berücksichtigt, auf einen signifikanten Zusammenhang zwischen dem aggregierten Konsum und dem Einkommen hindeutet. Nimmt man die Differenzen zwischen den einzelnen Werten der Zahlenreihen, so erweist sich ein gewisser Zusammenhang zwischen dem Einkommen eines Landes und seinem Konsum als wahrscheinlich. Die Strammheit dieses Zusammenhangs variiert allerdings stark von Land zu Land.

RÉSUMÉ

Les fonctions de consommation représentent une composante majeure de la théorie macroéconomique moderne. Les nombreuses recherches économétriques effectuées depuis 1930 ont en général été interprétées comme indicatrices d'une relation significative entre le revenu national et la consommation agrégée. On s'est servi fréquemment des tests classiques de signification pour vérifier les résultats obtenus de l'estimation des fonctions de consommation agrégées. Les séries de temps économiques utilisées dans cet article sont certainement insuffisantes, si on les compare aux suppositions de ces tests. Pour cette raison, on utilise dans cet exposé une méthode plus commune pour examiner la signification de ces études de corrélation et de régression.

Le test utilisé dans cet article se base sur l'estimation d'une fonction de consommation «internationale». On calcule une régression entre la consommation

du pays i et le revenu du pays j. Une fonction de consommation est admise comme significative, si la consommation du pays i est en corrélation plus étroite avec son propre revenu ($j = i$) qu'avec celui d'un autre pays ($j \neq i$). Nos résultats, se basant sur des séries de temps de la consommation agrégée et du revenu, ne nous ont pas permis de conclure, que la régression, qui implique la consommation et le revenu du même pays, indique une dépendance significative entre les deux séries. Les résultats obtenus des différences entre les valeurs isolées des séries numériques montrent une certaine relation entre le revenu d'un pays et sa consommation; mais l'intensité de cette relation varie fortement d'un pays à l'autre.